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BIOLOGY OF CYLINDROCOPTURUS FURNISSI BUCHANAN ON DOUGLAS FIR (PSEUDOTSUGA TAXIFOLIA (LAMB.) BRITT

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Forest Insect Laboratory,
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MEMORANDUM FOR MILLER AND EVENDEN

A manuscript, "Biology of Cylindrocopturus furnissi Buchanan on Douglas fir (Pseudotsuga taxifolia (Lamb.) Britt.," which has been prepared as a companion paper to be given with Eaton's paper on Cylindrocopturus eatoni at the Pasadena meetings, is enclosed for review. The manuscript is intended for later publication in the Journal of Economic Entomology. Your comments on it will be greatly appreciated.

F. P. Keen, Senior Entomologist,
Forest Insect Investigations.

By R. L. Furniss

R. L. Furniss

Good organization of a large body of facts - the essentials.

BIOLOGY OF *CYLINDROCOPTURUS FURNISSI* BUCHANAN ON DOUGLAS FIR (*PSEUDOTSUGA TAXIFOLIA* (LAMB.) BRITT.)[1]

R. L. Furniss[2]

United States Department of Agriculture
Bureau of Entomology and Plant Quarantine

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[1] A contribution from the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, in cooperation with the College of Forestry, University of Washington.

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[2] The author is indebted to W. K. Coulter and W. R. Pierce, temporary assistants, for aid in collecting the field data; and to D. M. Covington, resident manager of Pack Demonstration Forest, for much material assistance in carrying on the study.

For many years *Cylindrocopturus furnissi* Buchanan has been known to attack Douglas fir, *Pseudotsuga taxifolia* (Lamb.) Britt. Until recently, however, it has not been recognized as specifically distinct and as a result it has been confused in the literature under the name, *C. longulus* Leconte, with a number of closely related species that live principally in pines. Buchanan (1940) has described *C. furnissi*, discussed its systematic relationships, and noted its host and distribution. It is the purpose of the present paper to record its biology in relationship to its only known host, Douglas fir.

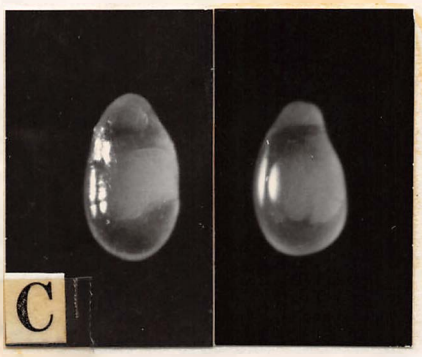
The observations recorded herein were made chiefly at Pack Demonstration Forest, La Grande, Wash., where a rather heavy infestation of a naturally established stand of 20-year-old Douglas fir has been in progress for a number of years. Some data were taken there as early as 1935, but no detailed study was undertaken until 1938. Observations were continued in 1939 and 1940 and concluded in the spring of 1941. Supplemental records were obtained from other places in western Washington and Oregon, and from northwestern California.

DISTRIBUTION.—When Buchanan (1940) described Cylindrocopturus furnissi, he had before him the type series from La Grande, and others from: Tenino, Wash.; Aurora Mills, Oswego, St. Helens, and Lane County, Oreg.; and Gasquet Ranger Station, Calif. Some additional records of distribution are now available. Localities where the weevil has been collected and which have not previously been recorded include: Carson, Fort Lewis, Nisqually, Puyallup, Shelton, Toledo, and Vashon, Wash.; and Grants Pass, Oreg.

CHARACTER AND IMPORTANCE OF ATTACKS.---Although Cylindrocopturus furnissi is widely distributed in the Douglas fir region, its presence is easily overlooked. Under ordinary conditions it attacks and frequently kills scattered small branches on open-grown reproduction. This type of infestation is inconspicuous and has no serious effect upon the attacked trees. Where small Douglas firs are growing on certain types of soil, such as the gravelly deposits at La Grande, heavy weeviling may occur year after year, deforming the trees and retarding their growth (pl. 1, A). Many of the laterals and terminals on such trees may be killed back, some of them as much as 8 to 10 years' growth. Not all the attacked branches are killed. Often the young brood stages are overcome by the resistance of the tree before the limbs are seriously affected (see discussion of host resistance). In other cases beetles may develop successfully without killing the infested branches. In the latter event callous tissue develops and gradually grows over the larval mines (pl. 1, B). If subsequent attacks do not kill such branches, they will eventually recover, provided they are not so weakened as to be broken off by wind or other forces. Some small trees, usually those less than 5 feet high, may be killed outright by C. furnissi. Once Douglas firs have attained a height of 15 to 20 feet they are no longer subject to appreciable damage by this weevil.

Plate 1.—*Cylindrocopturus furnissi* Buchanan: A, Weeviled terminal (X); B, callus formed over successful attack (X); C, eggs (X); D, mature larva (X); E, pupa (X); F, male adult (X).

Plate -1



Following drought, weeviling may increase to a very considerable extent. This was the case in the Rogue River Valley, Oreg., following the extremely dry summer and fall of 1936, and in the Puget Sound Basin, Wash., following the very dry summer of 1938. In both these areas many small trees growing on shallow or gravelly soils were heavily attacked. It was observed, however, that the weevils did not develop successfully in trees that were extremely desiccated from drought.

Under conditions that favor it, Cylindrocopturus furnissi may be a considerable factor in retarding the development of young stands by causing loss of growth and some killing in the early years. On a regional basis infestation by this weevil causes relatively little damage in naturally established stands, but in individual plantations it is likely to become quite important.

LIFE HISTORY AND HABITS.--There is one main generation and perhaps a partial second each year at La Grande, as determined by caging studies and periodic sampling of the 1938-39 and 1939-40 broods. The various stages are briefly described, and their observed habits are noted in the following discussion.

The adult (pl. 1, F) averages 2.5 mm. in length and 1.05 mm. in width. It is covered with intermixed dark and light scales that make it appear cupreous above and whitish beneath. A detailed description of the adult has been made by Buchanan (1940).

The sexes are quite similar in general appearance but can be readily separated on the character of the first abdominal ventrite. In the male this ventrite bears a concave impression that reaches the base. In the female the first ventrite is convex to flat or occasionally somewhat concave, but the concavity almost never reaches the base. Approximately 1 in 100 individuals is intermediate and difficult to determine by external examination; however, in a random sample consisting of 1,205 adults, which were subsequently dissected, all except two females and one male were correctly designated as to sex on the sole basis of the abdominal character.

Observations made during the study indicated an approximate 1:1 sex ratio. A summary of 8 small lots of adults, totaling 351 and reared from infested branches collected at various places in 1935, 1937, and 1939, showed that 51.2 per cent were females and 48.8 per cent were males. A combined collection of 3,141 adults, obtained by beating Douglas fir reproduction at La Grande at least once each month from June 1939 to May 1940, comprised 44.3 per cent females and 55.7 per cent males.

New adults were first formed by the third week in May and became most abundant in the pupal cells in the branches by the first week in July. Initial emergence occurred soon after the middle of June and was completed during the first week in August. Very soon after emergence the adults began to feed upon small branches of Douglas fir by cutting irregular holes through the outer bark and gouging out small cavities in the inner bark with the beak. These feeding punctures became callcused and, when abundant, imparted a characteristic roughened appearance to the branches. In some cases where 30 to 50 adults were caged on a single branch the calluses became so abundant that the branch was killed. On uncaged branches feeding punctures were not found abundant enough to cause mortality. No feeding on needles was observed. In cages feeding continued as long as the beetles were active and was essential to their survival. Field collections made during every month of the year indicated that it is normal for a large percentage of adults to overwinter on Douglas fir reproduction by clinging to the branches, and that many adults survive at least one year. In cages on living branches numerous adults were kept alive over winter and several lived approximately a year. In these cages maximum length of survival was 428 days for a male and 362 days for a female.

The egg (pl. 1, C) is ovoid, pearly white, and without surface markings. Average dimensions of 20 eggs measured on September 5, 1939, were: Length, .483 mm.; and width, .296 mm.

The process of egg laying was not observed; however, 4,389 eggs were dissected from twigs and practically all were found to have been deposited in the same manner. Each egg was laid individually in a small hole cut obliquely in the living bark, and the hole was then sealed with a white secretion. The presence of this white plug served to distinguish egg punctures from feeding punctures which were open and more irregular in shape. In the laboratory a few eggs were laid on the surface of twigs that had become excessively dry. In the field eggs were deposited in growth as far back as that of the tenth year, but a very large percentage of them were laid in the last four years' growth. The next to the current year's growth was observed to be most heavily attacked. The eggs were rather uniformly distributed along a given year's growth, with the exception of the current year's growth where eggs were found concentrated near the base of the internode.

There was a preoviposition period of approximately one month following emergence of the adults. Egg laying in the field began about the first of August, continued at a fairly high level until the middle of September, and then dropped off rapidly until it ceased by the first week in October. In the laboratory the egg laying period was extended approximately 3 months beyond that in the field by maintaining beetles at room temperatures in glass jars containing frequently replaced sections of fresh Douglas fir branches. A total of 175 adults (72 females and 103 males) were used in this experiment. Because of various hazards connected with the method of handling them, mortality among the caged beetles was high and the last one died early in January 1940. In the laboratory oviposition continued from August 9, 1939, to January 1, 1940, and peak productivity occurred near the time that egg laying ceased in the field. Mating occurred frequently among the caged beetles and seemed to be essential to the continued production of eggs, for productive females discontinued laying eggs within a few days after being deprived of association with males.

Some overwintered females resumed egg laying in the spring, but the relative abundance and the rate of development of the resulting progeny were not determined. It appears significant, however, that intensive sampling during spring and early summer at La Grande failed to reveal any evidence of attacks on uncaged trees before the first of August, the time when the main new generation was established. In contrast with this, dissections of overwintered adults, that were collected on April 28 and May 16, 1940, showed that most of the females contained mature eggs; whereas, from September 19, 1939, to March 19, 1940, only 3 of 443 females contained any mature eggs. Adults collected during February and subsequently kept in the laboratory deposited eggs by March 17. In cages on Douglas firs in the open, overwintered adults laid eggs which hatched as early as May 15 and such adults continued to be productive as late as August 15.

No attempt was made to determine the number of eggs laid by an individual female in the field. In the laboratory a careful record was made of egg production. One female caged with one male laid 184 eggs in 116 days, or an average of 1.5 eggs per day. This was the highest total productivity recorded for any female. Another female produced 147 eggs in 88 days, to average 1.6 eggs per day. A group of 7 females caged with 6 males laid 862 eggs, or an average of 123 eggs per female. Some isolated pairs laid very few eggs and some produced none at all. Dissections of numerous gravid females showed them to contain from one to eight large, apparently mature eggs.

Incubation was observed only in the laboratory. Eggs were obtained from caged weevils in glass jars containing sections of freshly cut Douglas fir branches. Feeding and oviposition were allowed for one to several days. Then the eggs were removed from the bark and placed upon moist blotting paper in salve boxes, which were closed and kept at room temperatures. With daily care to prevent desiccation and the development of mold, 271, or 75.3 per cent, hatched out of a total of 360 eggs that were isolated. As the technique of handling was improved, mortality became negligible. It is of interest that eggs laid in the laboratory long after egg laying had ceased in the field were also fertile. During August 1939 a total of 193 eggs of known age were isolated and kept under daily observation. The incubation period for these eggs varied from 4 to 13 days with 95 per cent hatching in 6 to 11 days. In the field the incubation period may have been somewhat longer.

The mature larva (pl. 1, D) is 3.0 to 3.5 mm. in length and approximately 1.2 mm. in maximum width. The body is curved and subcylindrical. The color is white, except for the head, which is light testaceous with darker mouth parts and a characteristic pigmented area on each gena. The prepupal larva, although of the same instar as the active mature larva, differs from it by being much less curved and by having the head excerted.

Upon hatching, principally during August and September, the small larvae soon bored down to the surface of the wood where they usually extended their galleries longitudinally for a variable distance. Later the galleries became more winding and frequently resulted in the girdling of small branches, especially at the nodes. On large branches coalescence of several galleries was commonly necessary before the branches were killed. As the galleries were extended the bark over them shrank, causing a characteristic callus which indicated the presence of attacks considerably before the foliage faded. When the larvae approached maturity, they frequently bored through the wood into the pith and mined in it for an inch or two. Larvae of all sizes overwintered. The last ones transformed to pupae by the first of July. No larvae were individually reared from the egg to the pupal stage, but periodic sampling of the population indicated a minimum larval period of approximately 9 months.

The pupa (pl. 1, E), which is white, approximately 3.5 mm. long, and bears a few inconspicuous setae, does not differ in general outline from the typical curculionid pupa.

Pupal cells were formed in the bark, in the wood, or in the pith. In the larger branches pupation commonly occurred wholly in the bark or partly in the bark and partly in the wood, but in the smaller branches it was more frequent in the wood or in the pith. Pupation took place in the spring, chiefly during May and June, but the first ones formed late in April and the last ones did not transform into adults until the end of the third week in July. Ninety-eight prepupal larvae were individually reared to the adult stage in the laboratory in order to determine the length of the pupal stage. Each of these larvae was placed in a small glass vial which was plugged with cotton and moistened daily. A total of 98 adults (46 females, 49 males, and 3 of undetermined sex) developed. The period covered by these observations extended from May 31 to July 21, 1939. The minimum time for complete development in the pupal stage was 14 days, the maximum 27 days, and the average 22 days. Actually the length of pupal life varied relatively little, for 90 per cent developed into adults in 20 to 23 days.

ASSOCIATED FUNGUS.[3]—A fungus, Hormiscium gelatinosum Hedg.,

[3] Identification and culturing of this fungus were done by C. T. Rumbold, Bureau of Plant Industry, United States Department of Agriculture. Inoculations and checking of results were done by J. W. Kimmey, J. L. Bedwell, T. W. Childs, and G. H. Englerth of the same bureau.

that causes blue staining of window sash and other pine products, was closely associated with Cylindrocopturus furnissi, and it is suspected of aiding this insect in overcoming the resistance of attacked trees. Cultures of the fungus, prepared from the weevil larvae and larval mines and inoculated into healthy trees in August 1940, became established in some cases and killed tissue around the points of inoculation but did not spread sufficiently to kill any of the inoculated branches or terminals. From this it was concluded that H. gelatinosum is only mildly pathogenic.

NATURAL CONTROL.—There are several important factors which limit the abundance of Cylindrocopturus furnissi. These are so effective that the weevil is ordinarily of no economic importance despite the fact that it has a rather high reproductive capacity and is able to develop successfully in trees of seemingly vigorous growth. The chief factors which have been observed as operative against C. furnissi are: Host resistance, competition, and parasitism. No detailed study has been made of the actual effectiveness of these factors and very likely their relative importance is variable from year to year.

Host resistance in this case is the "pitching out" of the weevil brood. By the time larval feeding ceases in the fall, a rather high mortality has occurred and much of it can be attributed to excessive pitch flow. General observations made during the examination of numerous infested branches showed that "pitching out" of eggs and very small larvae is especially prevalent. As the larvae increase in size and become well established, mortality resulting from host resistance decreases rapidly. A limited number of brood counts made in October and November 1939 showed mortality, exclusive of that caused by parasitism, to average 50 to 75 per cent. Practically all this mortality was caused by excessive pitch flow. A small sample indicated that, because of pitch infiltration, few if any eggs overwinter successfully.

Competition for suitable food and living space results in the mortality of many larvae. During the developmental period in the fall numerous eggs and small larvae are accidentally killed by larger larvae as the latter extend their galleries. When the winter period of inactivity begins, living larvae of all sizes may be present in a given branch. In the usual event of the branch being girdled, the probability is that only the mature or nearly mature larvae will survive, for by spring the bark tissue beyond the girdle is usually quite dry and unsuitable for the development of small larvae.

Parasitism is fairly common. Brood counts made between April 3 and August 10, 1939, of 22 lots of material infested by the 1938-39 generation revealed an average parasitism of 19.9 per cent of the larvae and pupae not dead from other causes. Information concerning the various species of parasites was obtained by the mass rearing of infested material, by numerous dissections of infested branches, and by the rearing of individual parasites that were isolated from weevil galleries and parasitized weevils. In all, 13 hymenopterous parasites were either definitely proven to be parasitic or linked as being very likely parasitic on Cylindrocopturus furnissi. The following are a few brief notes concerning these parasites.4/

4/ All parasites were determined by specialists of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture. The braconids were determined by C. F. W. Muesebeck, the chalcidoids by A.B. Gahan, and the ichneumonid by R. A. Cushman.

Dendrosoter scaber Mues. (Braconidae) was reared in considerable numbers during June and July 1937 from weeviled branches taken from drought-weakened Douglas firs near Gasquet Ranger Station. These branches had been attacked and killed by Cylindrocopturus furnissi, which is assumed to be the host. D. scaber was described by Muesebeck (1938) chiefly from adults from this rearing.

Microbracon pini Mues. (Braconidae) was an uncommon larval parasite of Cylindrocopturus furnissi. Two adults were reared on June 12, 1937, from weevil infested limbs of Douglas fir taken near Gasquet Ranger Station. One fully formed adult was removed from its cocoon in a larval mine of C. furnissi at Toledo on April 12, 1939. Four adults were reared in the laboratory during March 1941 from cocoons taken from mines of C. furnissi at La Grande.

Urosigalphus pini Cush. (Braconidae) was found only near Gasquet Ranger Station, and is assumed to be parasitic on Cylindrocopturus furnissi. Numerous adults were reared during June, July, and August, 1937, from Douglas fir branches infested with this weevil.

Euderus argyresthiae (Cwfd.) (Eulophidae) was the most abundant larval parasite of Cylindrocopturus furnissi at La Grande, Nisqually, Puyallup, and Toledo. The pupal period of 28 individuals ranged from 11 to 22 days. Adults were reared in the laboratory from April 18 to July 29, 1939, from the 1938-39 generation of C. furnissi; during October and November 1939, from the 1939-40 generation; and during March 1941, from the 1940-41 generation.

Tetrastichus sp. (Eulophidae) was recorded in association with Cylindrocopturus furnissi at Gasquet Ranger Station and Puyallup. At the former place three adults were reared in June 1937 from branches of Douglas fir containing C. furnissi, and at the latter place two adults were reared on May 15 and 16, 1939, from parasitised larvae of C. furnissi.

Eurytoma tomici Ashm. (Eurytomidae) adults were reared in small numbers from April 25 to August 5, 1939, from larvae of Cylindrocopturus furnissi taken at La Grande and Puyallup. The pupal period of six individuals ranged from 10 to 13 days.

Eupelmella vesicularis (Retz.) (Eupelmidae) was reared in small numbers from larvae of Cylindrocopturus furnissi taken at La Grande and Puyallup. The pupal period of six individuals ranged from 10 to 18 days. Adults emerged from June 28 to July 22, 1939. Graham (1933) says of this species, "This is apparently one of the most polyphagic species of all chalcidoids, its hosts embracing Diptera, Coleoptera, Hymenoptera, Lepidoptera, Hemoptera, and Orthoptera."

Calliephialtes comstockii (Cress.) (Ichneumonidae) was recorded on Cylindrocopturus furnissi only at La Grande where three adults were reared during June 1939 from larvae of this weevil.

Amblymerus near verditor Nort. (Pteromalidae) was reared in fair numbers during June 1937 from branches of Douglas fir weeviled by Cylindrocopturus furnissi near Gasquet Ranger Station. From April 30 to June 22, 1939, a few adults were reared from larvae of C. furnissi taken at La Grande and Toledo. The pupal period of two individuals was 13 and 15 days.

Caenacis sp. (Pteromalidae) was reared in small numbers during June, July, and August, 1939, from larvae of Cylindrocopturus furnissi taken at La Grande, Nisqually, and Puyallup.

Cecidostiba dendroctoni Ashm. (Pteromalidae) was reared in small numbers during April 1939 from larvae of Cylindrocopturus furnissi taken at La Grande, Nisqually, and Puyallup.

Rhopalicus pulchripennis (Cwfd.) (Pteromalidae) was reared in considerable numbers during June 1937 from branches of Douglas fir infested by Cylindrocopturus furnissi near Gasquet Ranger Station. At this locality R. pulchripennis was less abundant than Dendrosoter scaber and Urosigalphus pini. At La Grande, Nisqually, Puyallup, and Toledo it was reared from the larvae of C. furnissi and was second in abundance to Euderus argyresthiae.

An undetermined species of Hymenoptera was commonly found as a parasite of the adults of Cylindrocopturus furnissi at La Grande. Observations were not made to determine whether it occurred elsewhere. Dissections of 15 lots comprising a total of 925 adults of C. furnissi taken by beating from September 12, 1939, to May 16, 1940, revealed 12.5 per cent of them parasitized by this parasite; whereas, dissections of 3 lots totaling 215 adults collected in the same manner between July 29, 1940, and February 19, 1941, revealed 50 per cent of them parasitized. In all except 13 of the 223 weevils found to be parasitized by this species there was only 1 parasite larva to each host adult. In 12 weevils there were 2 parasite larvae and in 1 there were 3 parasite larvae. In all cases where there were more than one parasite larva only one had survived. The manner of egg deposition of the parasite was not observed. There seemed to be only one generation a year with larvae being present in the abdomen and occasionally the thorax of the host from July until May. The parasite larvae emerged from the weevils during May and June, but none has yet been reared to the adult stage.

ARTIFICIAL CONTROL.—No practical measures were developed for the control of this weevil, and none seems necessary under existing forest conditions. In anticipation of possible future needs, two measures, (1) destruction of the immature stages by removing and burning infested material, and (2) destruction of adults collected by beating during the preoviposition period, were investigated. Because of serious limitations both as to effectiveness and economy, neither of these measures can be recommended.

SUMMARY.—Cylindrocopturus furnissi is recorded only from western Washington and Oregon and from northwestern California. It is a minor pest of naturally established Douglas fir reproduction and a potential threat to plantations of this tree. Damage increases under drought conditions.

A detailed study of the biology of Cylindrocopturus furnissi was made from 1938 to 1941 chiefly at La Grande, Wash., where there is one main generation and perhaps a partial second each year. Larvae, parent adults, and possibly eggs overwinter. Pupae develop in late April and are present until late in July. Adults begin to form by May 20 but do not emerge until nearly a month later. The last ones leave the branches by early August. There is a preoviposition period of approximately one month. Oviposition takes place from the first of August to the first of October, and practically all eggs hatch before winter. Throughout their active life, adults feed upon the inner bark of small branches of Douglas fir. A large percentage of parent adults overwinter by clinging to the branches of the host. Some of these adults resume egg laying in the spring. A fungus, Hormiscium gelatinosum Hedg., is associated with C. furnissi and seems to aid the larvae in overcoming the resistance of attacked trees.

Natural control factors observed as affecting Cylindrocopturus furnissi are: Host resistance, competition, and parasitism. Thirteen species of Hymenoptera are recorded as parasites or probable parasites of this weevil. Artificial control is considered unnecessary under forest conditions, but may become necessary in plantations. No practical control measures have been developed.

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